USING FRACTIONAL DELAY COMPUTATIONS TO IMPROVE INTERMODULATION PERFORMANCE

TECHNICAL FIELD

[0001] The exemplary and non-limiting embodiments relate generally to wireless communication systems, methods, devices and computer programs and, more specifically, to using fractional delay computations to improve intermodulation performance.

BACKGROUND

[0002] This section is intended to provide a background or context. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] Many telecommunications systems require linear radio frequency (RE) power amplifiers. A linear amplifier produces an output signal that is linearly related to the signal applied to the input. An amplifier that compresses its input or has a non-linear input/output relationship may provide degraded intermodulation performance, potentially resulting in interference to other radio channels.

[0004] Predistortion is a technique that has been used to improve the linearity of RF power amplifiers. A predistortion circuit inversely models the gain and phase characteristics of the RF power amplifier. When the predistortion circuit is combined with the RF power amplifier, the result is an overall system having enhanced linearity and reduced distortion. In essence, "inverse distortion" is introduced into the input of the RF power amplifier, thereby cancelling any non-linearity the RF power amplifier might otherwise exhibit. Predistortion is a cost-saving technique that enhances power efficiency. RF power amplifiers tend to become more non-linear as their output power increases towards their maximum rated output. Predistortion may be employed to obtain more usable power from the amplifier without having to build a larger, less efficient and more expensive amplifier.

[0005] Predistortion may be implemented in the analogue domain as well as the digital domain. For example, some present-day radio transmitters support Digital Pre-Distortion (DPD) for improving intermodulation performance. DPD techniques bring increased power efficiencies to the transmitter, resulting in considerable power savings for users. While it is possible to implement efficiency enhancement techniques within the context of analog devices, DPD algorithms provide additional efficiencies that could not have been achieved solely within analog domain.

[0006] DPD is effective at improving intermodulation performance when all inputs to the DPD process are accurate. Some of the key inputs to the Digital Pre-Distortion algorithm are: a) an undistorted transmitted signal; b) a feedback signal; and c) a suitable mathematical model for the radio frequency (RF) power amplifier used by the transmitter. As part of the DPD approach, the undistorted transmitted signal has to be synchronized with the feedback signal. Correct synchronization will match a sample of the transmitted signal to a correct feedback sample. Usually a timing offset has to be computed to define the match from the transmitted signal to the feedback signal. This offset is commonly known as either the timing offset or simply the delay. Throughout this specification, the word "delay" is used to refer to the timing offset between the transmitter and the feedback signal.

[0007] In order to achieve enhanced DPD performance, it is important to determine an accurate delay. For most waveforms, this delay has been defined in terms of integer samples of the DPD rate. One example of an integer sample is 1/(307.2 MHz), or 3.25 nanoseconds, where 307.2 Mega-Samples Per Second (MSPS) is the sampling rate or the processing rate. For some waveforms and their occupied bandwidths, determining an integer delay is not adequate.

SUMMARY

[0008] This summary section is intended to be merely exemplary and non-limiting.

[0009] The foregoing and other problems are overcome, and other advantages are realized, by the use of the exemplary embodiments.

[0010] In a first aspect thereof, a set of exemplary embodiments provides methods for enhancing the intermodulation performance of an RF power amplifier by determining, estimating, or computing a coarse time delay represented by an integer T1; determining or selecting a current reference point for a transmitted signal waveform of an RF power amplifier; shifting the transmitted signal waveform by a set of offsets comprising a plurality of non-integer fractional steps from (T1−Xd) to (T1+Xd) where T1 is the integer and Xd is a non-integer fractional step size value for defining the plurality of non-integer fractional steps about the integer T1 such that the non-integer fractional steps progress in a positive direction as well as a negative direction from the integer T1; at each of the plurality of non-integer fractional steps, correlating the transmitted signal waveform with a feedback signal waveform to obtain a respective correlation value for each of corresponding fractional steps of the plurality of non-integer fractional steps; obtaining a correct fractional delay value by selecting a fractional step of the plurality of non-integer fractional steps having a highest respective correlation value; applying the obtained correct fractional delay value to the transmitted signal waveform to provide a compensated transmitted signal waveform, and combining the compensated transmitted signal waveform with the feedback signal waveform to reduce or eliminate at least one intermodulation product of the RF power amplifier.

[0011] In a second aspect thereof, a set of exemplary embodiments provides an apparatus for enhancing the intermodulation performance of an RF power amplifier. The apparatus includes at least one processor and at least one memory storing computer program code. The at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to perform actions. These actions include determining, estimating, or computing a coarse time delay represented by an integer T1; determining or selecting a current reference point for a transmitted signal waveform of an RF power amplifier; shifting the transmitted signal waveform by a set of offsets comprising a plurality of non-integer fractional steps from (T1−Xd) to (T1+Xd) where T1 is the integer and Xd is a non-integer fractional step size value for defining the plurality of non-integer fractional steps about the integer T1 such that the non-integer fractional steps progress in a positive direction as well as a negative direction from the integer T1; at each of the plurality of non-integer fractional steps, correlating the transmitted signal waveform with a feedback signal waveform to obtain a respective cor-